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# Thermofluid topology optimization of heat sinks

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## Topology optimization

Topology optimization [1,2] is concerned with optimizing a material distribution within a design domain under given constraints. In contrast to size and shape optimization, topology optimization does not rely on an initial design parametrization which can lead to reduced development time and identification of unintuitive and unanticipated designs.

## Project aim

Efficient heat transfer is critical for the overall performance of caloric devices. Our project deals with density-based topology optimization of heat exchangers and heat sinks as well as fabrication and experimental validation of these devices. It aims at demonstrating that thermofluid topology optimization is a viable design tool not only for academic problems but also for real world engineering challenges.

## Forced convection heat sink optimization

A pseudo 3D heat sink model [3] consisting of a thermally coupled 2D thermofluid design layer and a conducting metal base plate are used to generate optimized heat sink designs. A laminar steady-state flow is assumed in the optimization model. The optimization objective is to minimize the heat sink heat transfer resistance for a fixed pressure drop over the heat sink and a fixed heat production rate in the base plate. 3D validation simulations with a body-fitted mesh are conducted to validate the simplified optimization model and a good agreement between the models is found.

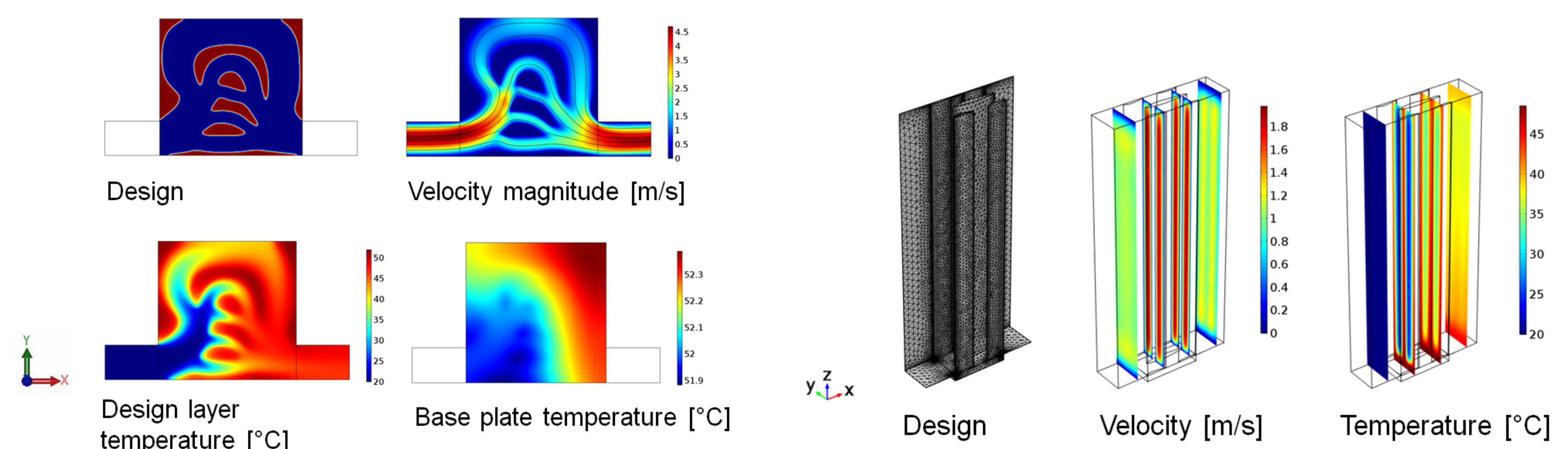


Fig. 1: Exemplary optimized design and corresponding multiphysics results.

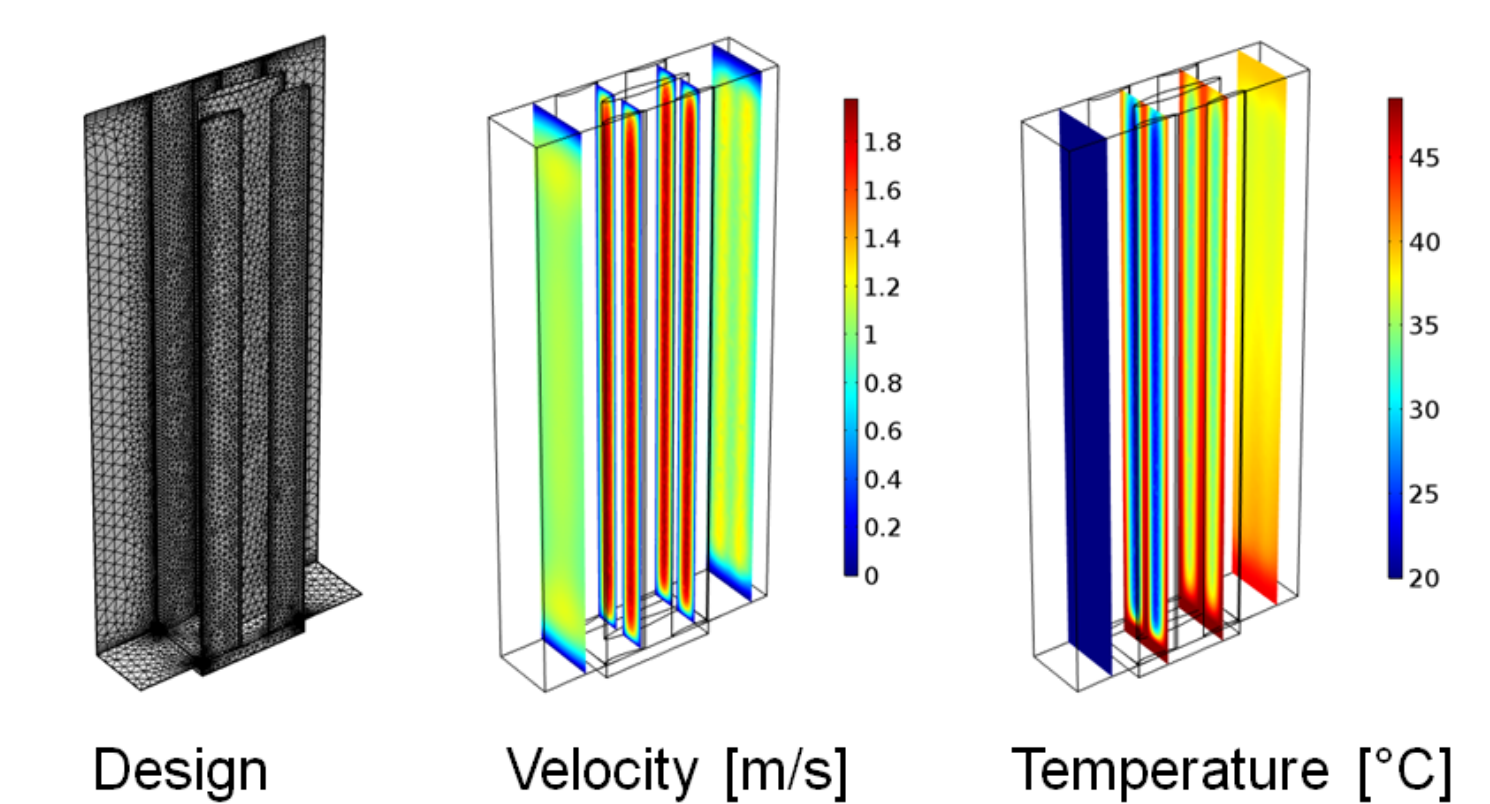


Fig. 2: 3D validation model with body-fitted mesh.

## Natural convection heat sink optimization and experimental validation

Heat sinks cooled by natural convection are optimized using a large-scale 3D thermofluid topology optimization model in which a steady-state laminar flow is assumed [4]. Prototypes of optimized designs are fabricated by investment casting of Britannia alloy. Investment casting can yield dense parts with high strength and high thermal conductivity at a low cost compared to direct additive manufacturing of the metal heat sink (e.g. metal selective laser melting). The topology optimized heat sinks are benchmarked against baseline pin fin heat sink designs and a superior performance of the topology optimized designs is found at the conditions for which they are optimized.

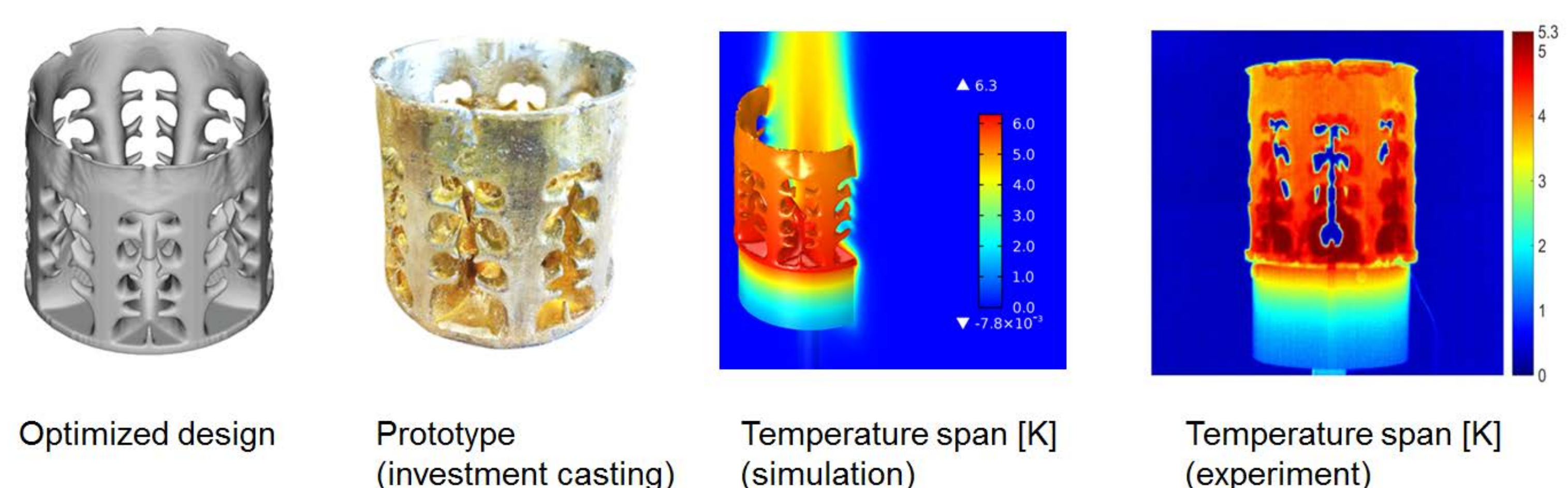


Fig. 3: Exemplary results of the natural convection heat sink optimization.

## References

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- [2] T. Dbouk, "A review about the engineering design of optimal heat transfer systems using topology optimization", *Applied Thermal Engineering* 112 (2017) 841 - 854
- [3] J. Haertel et al., "Topology Optimization of a Pseudo 3D Thermofluid Heat Sink Model", under review
- [4] J. Alexandersen et al., "Large scale three-dimensional topology optimisation of heat sinks cooled by natural convection", *International Journal of Heat and Mass Transfer* 100 (2016) 876 - 891

## Conclusions and outlook

It is shown that topology optimization models can be used to generate practical heat sink designs with improved performance compared to standard benchmark structures. Current and future work in the field of thermofluid topology optimization involves, among others, large-scale 3D optimization, RANS-modeling, and transient problems.

## Acknowledgments

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